

# Arbitrary/Function Generator

## AFG2021 Datasheet



The AFG2021 Arbitrary Function Generator gives you the power to create the signals you need at an entry-level price. With 20 MHz bandwidth, 14-bit resolution, and 250 MS/s sample rate, you can generate all manner of signals -- from complex serial data streams to simple audio frequencies or clock signals to the output of an airbag sensor during a crash. With 12 standard waveforms, modulation capability, and a built-in noise generator, you can quickly create the signal you need to thoroughly exercise your designs.

### Key performance specifications

- 20 MHz sine, 10 MHz pulse waveforms provide coverage for your most common applications
- 250 MS/s sampling rate and 14-bit vertical resolution enable the creation of high-fidelity signals

### Key features

- The innovative UI reduces setup and evaluation time with direct access to frequently used functions and parameters
- The internal 4 × 128 kS memory and the USB memory expansion capability provide substantial capacity for defining complex waveforms
- USB remote control port and USB flash drive port are included. GPIB and LAN interfaces are available as an option
- Built-in Modulation, Noise Generator, Burst, and Sweep modes for greater versatility
- Built-in waveforms provide quick access to commonly used signals
- Large 3.5 inch color screen displays both graphical and numeric waveform information simultaneously
- Menu and online help in 8 languages

- 2U height and half-rack width fits both benchtop and rack-mounted applications
- Free ArbExpress software makes waveform editing and downloading extremely easy
- Free SignalExpress software combines Tektronix bench instruments into a low-cost solution for automatic testing

### Applications

- Electronic test and design
- Sensor simulation
- Education and training
- Functional test
- System integration

### Superior performance at an affordable price

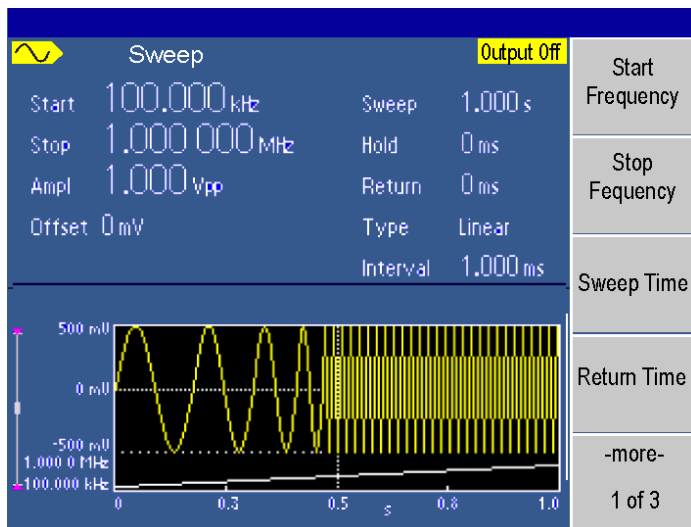
Most electronic devices, circuits, and systems are designed to handle some form of a signal. These signals can be simple like an audio frequency or clock signal or more complex like a serial data stream or the output of an airbag sensor during a crash. With 20 MHz bandwidth, 14-bit resolution, and 250 MS/s sample rate, the AFG2021 Arbitrary Function Generator can create both simple and complex signals at an entry-level price. With 12 standard waveforms, modulation capability, and a built-in noise generator, you can quickly create the signal you need to thoroughly exercise your designs.

### Intuitive user interface

The innovative ease-of-use features first seen on the AFG3000 Series arbitrary/function generators are the building blocks for the AFG2021, providing quick access to setup and operational features. Experienced AFG3000 users will find it especially easy to set up the new AFG2021. A 3.5 inch color TFT screen shows relevant parameters in both graphic and text formats, so you can have full confidence in your settings and focus on the task at hand. The front-panel shortcut buttons and rotary knob provide quick access to the most frequently used functions and settings.

## Excellent frequency agility

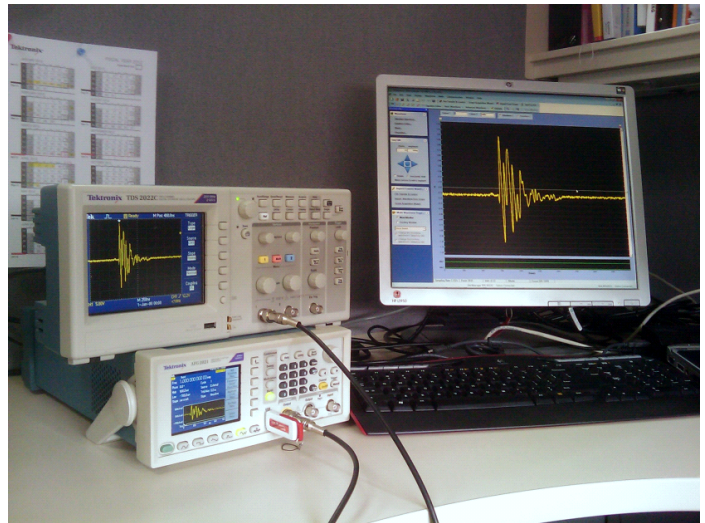
Traditional function generators created their output signals using analog oscillators and signal conditioning. The Tektronix AFG2021 relies on Direct Digital Synthesis (DDS) techniques. DDS technology synthesizes waveforms by using a single clock frequency to generate any frequency within the instrument's range. DDS architecture provides exceptional frequency agility, making it possible to program fast frequency and phase changes, which is useful for testing radio and satellite system components, amplifiers, and filters.



Frequency range from 1  $\mu$ Hz to 20 MHz, supports a wide range of amplifier and filter testing applications.

## ArbExpress for real-world waveforms with minimal effort

With ArbExpress software, you can quickly create waveforms that can be copied to the AFG2021 to meet custom stimulus requirements. ArbExpress supports direct connection to Tektronix oscilloscopes and AFGs through USB, GPIB, or LAN. The software allows you to import real-world signals captured with an oscilloscope onto a PC, then edit and download them onto an AFG to duplicate the captured waveform. This is extremely useful for automotive, medical, and industrial applications where recreating sensor output is critical to analyzing the integrity of the design.



ArbExpress software helps you easily duplicate real-world signals.

## Insert productivity with SignalExpress

Every AFG2021 ships with a free copy of the Tektronix Edition of National Instrument's LabVIEW SignalExpress software for basic instrument control, data logging, and analysis. SignalExpress supports the range of Tektronix bench instruments enabling you to connect your entire test bench. You can then access each instrument from one intuitive software interface. This allows you to automate complex measurements requiring multiple instruments, log data for an extended period of time, time-correlate data from multiple instruments, and easily capture and analyze your results, all from your PC. Only Tektronix offers a connected test bench of intelligent instruments to simplify and speed debug of your complex design.

## Connectivity

Using the front-panel USB host port, you can save your customized waveforms or instrument settings onto a USB memory stick. Reloading the data is easily done by plugging the device back into the USB host port. The USB device port and optional GPIB/LAN ports provide multiple alternatives for connecting the AFG2021 to your PC for waveform download and remote control.

## Compact form factor

The 2U height and half-rack width form factor allow the AFG2021 to be stacked on other bench instruments, such as digital multimeters, power supplies, and frequency counters, saving valuable bench space. With the optional RMU2U rackmount kit, GPIB interface, and full SCPI support, the AFG2021 is a perfect solution for automated test systems.

# Specifications <sup>1</sup>

## Model overview

|           | AFG2021   |
|-----------|---|
| Channels  | 1   |
| Waveforms | Sine, Square, Pulse, Ramp, Noise, DC, Sin(x)/x, Gaussian, Lorentz, Exponential Rise, Exponential Decay, and Haversine |

## General characteristics

|   |  |
|---|--|
| <b>Sine wave</b>                                    | 1 $\mu$ Hz to 20 MHz   |
| <b>Sine wave in Burst Mode</b>                      | 1 $\mu$ Hz to 10 MHz   |
| <b>Effective maximum frequency out</b>              | 20 MHz   |
| <hr/>   |  |
| <b>Amplitude flatness (1 <math>V_{p-p}</math>)</b>  |  |
| <5 MHz  | $\pm 0.15$ dB ( $\pm 0.05$ dB, typical)                      |
| 5 MHz to 20 MHz                                     | $\pm 0.3$ dB ( $\pm 0.02$ dB, typical)                       |
| <hr/>   |  |
| <b>Harmonic distortion (1 <math>V_{p-p}</math>)</b> |  |
| 10 Hz to 20 kHz                                     | <-70 dBc (<-77 dBc, typical)                                 |
| 20 kHz to 1 MHz                                     | <-60 dBc (<-72 dBc, typical)                                 |
| 1 MHz to 10 MHz                                     | <-50 dBc (<-55 dBc, typical)                                 |
| 10 MHz to 20 MHz                                    | <-40 dBc (<-55 dBc, typical)                                 |
| THD   | <0.2% (<0.15%, typical) 10 Hz to 20 kHz, 1 $V_{p-p}$         |
| <hr/>   |  |
| <b>Spurious (1 <math>V_{p-p}</math>)</b>            |  |
| 10 Hz to 1 MHz                                      | <-60 dBc (<-71 dBc, typical)                                 |
| 1 MHz to 20 MHz                                     | <-50 dBc (<-68 dBc, typical)                                 |
| <hr/>   |  |
| <b>Phase noise, typical</b>                         | 20 MHz: <-110 dBc/Hz at 10 kHz offset, 1 $V_{p-p}$           |
| <hr/>   |  |
| <b>Residual clock noise</b>                         | -63 dBm  |
| <hr/>   |  |
| <b>Square wave</b>                                  | 1 $\mu$ Hz to 10 MHz   |
| <b>Rise/fall time</b>                               | $\leq 18$ ns   |
| <b>Jitter (RMS)</b>                                 | <500 ps (<60 ps, typical)                                    |
| <hr/>   |  |
| <b>Ramp wave</b>                                    | 1 $\mu$ Hz to 200 kHz  |
| <b>Linearity</b>                                    | $\leq 0.1\%$ of peak output at 10% to 90% of amplitude range |
| <b>Symmetry</b>                                     | 0.0% to 100.0%   |
| <hr/>   |  |
| <b>Pulse wave</b>                                   | 1 mHz to 10 MHz  |
| <b>Pulse width</b>                                  | 30.00 ns to 999.99 s   |
| <b>-- Resolution</b>                                | 10 ps or 5 digits  |
| <b>Pulse duty</b>                                   | 0.001% to 99.999% (Limitations of pulse duty width apply)    |
| <b>Edge transition time</b>                         | 18 ns to $0.625 \times$ Pulse Period                         |
| <b>-- Resolution</b>                                | 10 ps or 4 digits  |

<sup>1</sup> The given typical values are not warranted. But 80% or more manufactured units will perform to the level indicated at room temperature (approximately 25 °C).

**General characteristics**

|  |  |
|--|--|
| <b>Lead delay</b>                        |  |
| -- Range                                 | Continuous Mode: 0 ps to Period Trigger/Gate Burst Mode: 0 ps to Period – [Pulse Width + 0.8 × (Leading Edge Time + Trailing Edge Time)]   |
| -- Resolution                            | 10 ps or 8 digits  |
| Overshoot                                | <5%, typical   |
| Jitter (RMS)                             | <500 ps (<90 ps, typical)  |
| <b>Other waveforms</b>                   | 1 μHz to 200 kHz   |
| <b>Noise bandwidth (-3 dB)</b>           | 20 MHz   |
| <b>Noise type</b>                        | White Gaussian   |
| <b>DC (into 50 Ω)</b>                    | -5 V to +5 V   |
| <b>Arbitrary waveforms</b>               | 1 MHz to 10 MHz  |
| <b>Arbitrary waveforms in Burst Mode</b> | 1 MHz to 5 MHz   |
| <b>Effective analog bandwidth</b>        | 34 MHz   |
| <b>Nonvolatile memory</b>                | 4 waveforms  |
| <b>Memory: sample rate</b>               | 2 to 128 k: 250 MS/s   |
| <b>Vertical resolution</b>               | 14 bits  |
| <b>Rise/fall time</b>                    | ≤20 ns   |
| <b>Jitter (RMS)</b>                      | 4 ns   |
| <b>Amplitude</b>                         |  |
| <b>Range</b>                             | 50 Ω load: 1 mV <sub>p-p</sub> to 10 V <sub>p-p</sub><br>Open circuit: 2 mV <sub>p-p</sub> to 20 V <sub>p-p</sub>                          |
| <b>Accuracy</b>                          | ±(1% of setting + 1 mV), (1 kHz sine waveform, 0 V offset, >10 mV <sub>p-p</sub> amplitude)  |
| <b>Resolution</b>                        | 0.1 mV <sub>p-p</sub> , 0.1 mV <sub>rms</sub> , 1 mV, 0.1 dBm, or 4 digits   |
| <b>Units</b>                             | V <sub>p-p</sub> , V <sub>rms</sub> , dBm (sine wave only)   |
| <b>Output impedance</b>                  | 50 Ω   |
| <b>Load impedance setting</b>            | Selectable: 50 Ω, 1 Ω to 10.0 kΩ, high Z (adjusts displayed amplitude according to selected load impedance)                                |
| <b>Isolation</b>                         | <42 V <sub>peak</sub> maximum to earth   |
| <b>Short-circuit protection</b>          | Signal outputs are robust against permanent shorts against floating ground   |
| <b>External voltage protection</b>       | To protect signal outputs against external voltages use fuse adapter 013-0345-00   |
| <b>DC offset</b>                         |  |
| <b>Range</b>                             | 50 Ω load: ±(5 V <sub>peak</sub> – amplitude V <sub>p-p</sub> /2)<br>Open circuit: ±(10 V <sub>peak</sub> – amplitude V <sub>p-p</sub> /2) |
| -- Accuracy                              | ±(1% of  setting  + 5 mV + 0.5% of amplitude (V <sub>p-p</sub> ))  |
| -- Resolution                            | 1 mV   |

## Modulation characteristics

### AM, FM

|                                      |   |
|--------------------------------------|---|
| <b>Carrier waveforms</b>             | All, including ARB, except pulse, noise, and DC   |
| <b>Source</b>                        | Internal/external   |
| <b>Internal modulating waveform</b>  | Sine, square, ramp, noise, ARB (AM: maximum waveform length 4,096; FM: maximum waveform length 2,048) |
| <b>Internal modulating frequency</b> | 2 mHz to 50.00 kHz  |
| <b>AM modulation depth</b>           | 0.0% to +120.0%   |
| <b>Min FM peak deviation</b>         | DC  |
| <b>Max FM peak deviation</b>         | 10 MHz  |

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### Pulse width modulation

|                                      |  |
|--------------------------------------|--|
| <b>Carrier waveform</b>              | Pulse  |
| <b>Source</b>                        | Internal/external  |
| <b>Internal modulating waveform</b>  | Sine, square, ramp, noise, ARB (Maximum waveform length 2,048) |
| <b>Internal modulating frequency</b> | 2 mHz to 50.00 kHz   |
| <b>Deviation</b>                     | 0% to 50.0% of pulse period                                    |

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### Sweep

|   |  |
|---|--|
| <b>Waveforms</b>                                    | All, including ARB, except pulse, noise, and DC                  |
| <b>Type</b>   | Linear, logarithmic  |
| <b>Sweep time</b>                                   | 1 ms to 300 s  |
| <b>Hold/return time</b>                             | 0 ms to 300 s  |
| <b>Max total sweep time (Sweep + hold + return)</b> | 300 s  |
| <b>Resolution</b>                                   | 1 ms or 4 digits   |
| <b>Total sweep time accuracy, typical</b>           | 0.4%   |
| <b>Min start/stop frequency</b>                     | All except ARB: 1 $\mu$ Hz<br>ARB: 1 mHz                         |
| <b>Max start/stop frequency</b>                     | Sine: 20 MHz<br>Square: 10 MHz<br>ARB: 10 MHz<br>Others: 200 kHz |

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### Burst

|                                 |  |
|---------------------------------|--|
| <b>Waveforms</b>                | All, including ARB, except noise and DC              |
| <b>Type</b>                     | Triggered, gated (1 to 1,000,000 cycles or infinite) |
| <b>Internal trigger rate</b>    | 1 $\mu$ s to 500.0 s                                 |
| <b>Gate and trigger sources</b> | Internal, external, manual trigger                   |

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## Auxiliary input characteristics

### Modulation input

|                        |  |
|------------------------|--|
| <b>Input range</b>     | All except FSK: $\pm 1$ V full scale<br>FSK: 3.3 V logic level |
| <b>Impedance</b>       | 10 k $\Omega$  |
| <b>Frequency range</b> | DC to 25 kHz (122 kS/s sample rate)                            |

### External triggered/gated burst input

|                              |   |
|------------------------------|---|
| <b>Level</b>                 | TTL compatible                                  |
| <b>Pulse width</b>           | 100 ns minimum                                  |
| <b>Slope</b>                 | Positive/negative selectable                    |
| <b>Trigger delay</b>         | 0.0 ns to 85.000 s                              |
| <b>Resolution</b>            | 100 ps or 5 digits                              |
| <b>Jitter (RMS), typical</b> | Burst: <500 ps (Trigger input to signal output) |

### 10 MHz reference input

|                                     |   |
|-------------------------------------|---|
| <b>Impedance</b>                    | 1 k $\Omega$ , AC coupled                   |
| <b>Required input voltage swing</b> | 100 mV <sub>p-p</sub> to 5 V <sub>p-p</sub> |
| <b>Lock range</b>                   | 10 MHz $\pm$ 35 kHz                         |

## Auxiliary output characteristics

### Trigger output

|                              |  |
|------------------------------|--|
| <b>Level</b>                 | Positive TTL level pulse into 1 k $\Omega$                         |
| <b>Impedance</b>             | 50 $\Omega$  |
| <b>Jitter (RMS), typical</b> | 500 ps   |
| <b>Max frequency</b>         | 4.9 MHz (4.9 MHz to 20 MHz: A fraction of the frequency is output) |

## Common characteristics

### Remote programming

(GPIB, LAN 10BASE-T/100BASE-TX, USB 1.1, compatible with SCPI-1999.0 and IEEE 488-2 standards)

| Characteristic  | USB   | LAN <sup>2</sup> | GPIB <sup>2</sup> |
|---|-------|------------------|-------------------|
| Function change   | 95 ms | 103 ms           | 84 ms             |
| Frequency change  | 2 ms  | 19 ms            | 2 ms              |
| Amplitude change  | 60 ms | 67 ms            | 52 ms             |
| Select user ARB   | 88 ms | 120 ms           | 100 ms            |
| Data download time for 4k point ARB waveform data (8 KB), typical | 20 ms | 84 ms            | 42 ms             |

<sup>2</sup> GPIB and LAN interfaces are only available on the instrument with Option GL.

## System characteristics

|   |  |
|---|--|
| <b>Frequency setting resolution</b>       | 1 $\mu$ Hz or 12 digits  |
| <b>Phase (except DC, Noise, Pulse)</b>    |  |
| <b>Range</b>                              | -360° to +360°   |
| <b>Resolution</b>                         | Sine: 0.01°<br>Other Waveforms: 0.1°   |
| <b>Internal noise add</b>                 |  |
| <b>Level</b>                              | When activated, output signal amplitude is reduced to 50%  |
| <b>Resolution</b>                         | 0.0% to 50% of amplitude ( $V_{p-p}$ ) setting<br>1%   |
| <b>Main output</b>                        | 50 $\Omega$  |
| <b>Internal frequency response</b>        |  |
| <b>Stability</b>                          | All except ARB: $\pm 1$ ppm, 0 °C to 50 °C<br>ARB: $\pm 1$ ppm $\pm 1$ $\mu$ Hz, 0 °C to 50 °C           |
| <b>Aging</b>                              | $\pm 1$ ppm per year   |
| <b>Power source</b>                       | 100 V to 240 V, 50 Hz to 60 Hz or 115 V, 400 Hz  |
| <b>Power consumption</b>                  | 60 W   |
| <b>Warm up time, typical</b>              | 20 minutes   |
| <b>Power on self diagnostics, typical</b> | <10 s  |
| <b>Accoustic noise, typical</b>           | <50 dBA  |
| <b>Display</b>                            | 3.5 in. Color TFT LCD  |
| <b>User interface and help language</b>   | English, French, German, Japanese, Korean, Simplified and Traditional Chinese, Russian (user selectable) |

## Physical characteristics

|                   |                      |
|-------------------|----------------------|
| <b>Dimensions</b> |                      |
| <b>Height</b>     | 104.2 mm (4.10 in.)  |
| <b>Width</b>      | 241.8 mm (9.52 in.)  |
| <b>Depth</b>      | 419.1 mm (16.50 in.) |
| <b>Weight</b>     |                      |
| <b>Net</b>        | 2.87 kg (6.3 lb.)    |
| <b>Shipping</b>   | 4.72 kg (10.4 lb.)   |

**EMC, environmental, and safety characteristics**

**Temperature**

|                      |                  |
|----------------------|------------------|
| <b>Operating</b>     | 0 °C to +50 °C   |
| <b>Non-operating</b> | -30 °C to +70 °C |

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**Humidity**

|                      |  |
|----------------------|--|
| <b>Operating</b>     | ≤80%, +0 °C to +40 °C, noncondensing         |
|                      | ≤60%, +40 °C to +50 °C, noncondensing        |
| <b>Non-operating</b> | 5% to 90%, <+40 °C, noncondensing            |
|                      | 5% to 80%, ≥+40 °C to ≤+60 °C, noncondensing |
|                      | 5% to 40%, >+60 °C to ≤+70 °C, noncondensing |

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**Altitude**

|                      |                             |
|----------------------|-----------------------------|
| <b>Operating</b>     | Up to 3,000 m (9,842 ft.)   |
| <b>Non-operating</b> | Up to 12,000 m (39,370 ft.) |

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|                       |                                  |
|-----------------------|----------------------------------|
| <b>EMC compliance</b> | EU Council Directive 2004/108/EC |
|-----------------------|----------------------------------|

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|               |                                 |
|---------------|---------------------------------|
| <b>Safety</b> | UL61010-1; 2004                 |
|               | CAN/CSA C22.2 No. 61010-1; 2004 |
|               | EN61010-1; 2001                 |
|               | IEC61010-1; 2001                |

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## Ordering information

### Models

|                  |   |
|------------------|---|
| <b>AFG2021</b>   | Arbitrary/function generator  |
| <b>Includes:</b> | User manual, power cord, USB cable, CD-ROM with programmer manual, service manual, Labview and IVI Drivers, CD-ROM with ArbExpress® software, NIST-traceable calibration certificate. |
|                  | Please specify power cord and local language for user manual when ordering.   |

### Instrument options

#### Configuration options

|               |                         |
|---------------|-------------------------|
| <b>Opt GL</b> | GPIB and LAN interfaces |
|---------------|-------------------------|

#### Language options

|                 |                            |
|-----------------|----------------------------|
| <b>Opt. L0</b>  | English manual             |
| <b>Opt. L1</b>  | French manual              |
| <b>Opt. L2</b>  | Italian manual             |
| <b>Opt. L3</b>  | German manual              |
| <b>Opt. L4</b>  | Spanish manual             |
| <b>Opt. L5</b>  | Japanese manual            |
| <b>Opt. L6</b>  | Portuguese manual          |
| <b>Opt. L7</b>  | Simplified Chinese manual  |
| <b>Opt. L8</b>  | Traditional Chinese manual |
| <b>Opt. L9</b>  | Korean manual              |
| <b>Opt. L10</b> | Russian manual             |
| <b>Opt. L99</b> | No manual                  |

Language options include translated front-panel overlay for the selected language(s).

#### Power plug options

|                 |  |
|-----------------|--|
| <b>Opt. A0</b>  | North America power plug (115 V, 60 Hz)  |
| <b>Opt. A1</b>  | Universal Euro power plug (220 V, 50 Hz) |
| <b>Opt. A2</b>  | United Kingdom power plug (240 V, 50 Hz) |
| <b>Opt. A3</b>  | Australia power plug (240 V, 50 Hz)      |
| <b>Opt. A5</b>  | Switzerland power plug (220 V, 50 Hz)    |
| <b>Opt. A6</b>  | Japan power plug (100 V, 50/60 Hz)       |
| <b>Opt. A10</b> | China power plug (50 Hz)                 |
| <b>Opt. A11</b> | India power plug (50 Hz)                 |

## Datasheet

|          |                           |
|----------|---------------------------|
| Opt. A12 | Brazil power plug (60 Hz) |
| Opt. A99 | No power cord             |

### Service options

|           |   |
|-----------|---|
| Opt. C3   | Calibration Service 3 Years   |
| Opt. C5   | Calibration Service 5 Years   |
| Opt. D1   | Calibration Data Report   |
| Opt. D3   | Calibration Data Report 3 Years (with Opt. C3)  |
| Opt. D5   | Calibration Data Report 5 Years (with Opt. C5)  |
| Opt. R5   | Repair Service 5 Years (including warranty)   |
| Opt. R5DW | Repair Service Coverage 5 Years (includes product warranty period). 5-year period starts at time of instrument purchase |

## Accessories

### Recommended accessories

|             |                              |
|-------------|------------------------------|
| RM2U        | Rackmount kit                |
| 013-0345-00 | Fuse adapter, BNC-P to BNC-R |
| 159-0454-00 | Fuse set, 3 pcs, 0.125 A     |
| 012-0482-00 | BNC cable shielded, 3 ft.    |
| 012-1256-00 | BNC cable shielded, 9 ft.    |
| 012-0991-00 | GPIB cable, double shielded  |
| 011-0049-02 | 50 $\Omega$ BNC terminator   |



### Warranty

Three-year warranty on parts and labor.



Tektronix is registered to ISO 9001 and ISO 14001 by SRI Quality System Registrar.



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**For Further Information.** Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit [www.tektronix.com](http://www.tektronix.com).

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